Science Activity Plan:

Growing a Plant on the Moon: A Ground Control in Your Classroom!

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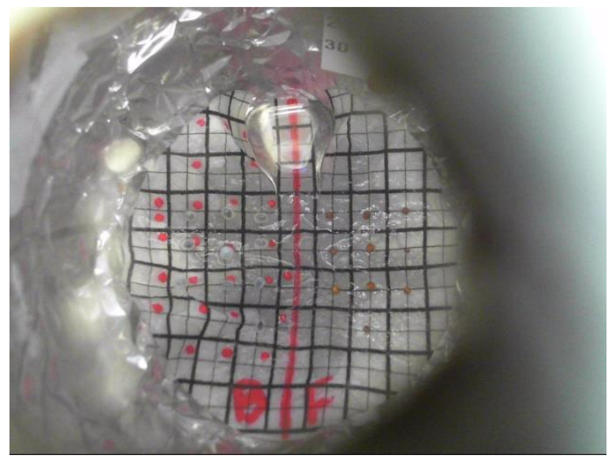
Background and Introduction



Be part of the excitement; help scientists learn how to grow plants on the moon!

For the first time ever, scientists will grow plants on the moon! The success of long term space missions will depend on the ability of astronauts to grow their own food and this mission will be the first step toward gardening on other worlds. In 2015, a chamber to grow plants will blast off, fly through space for 4 days then land on the moon. This chamber will be sealed, have a small window on the top and a camera attached on the inside to watch the plants grow. On their trip to the moon, the dry seeds will be exposed to extreme temperatures and radiation. Upon landing, a signal will be sent to add water to the seeds. Scientists will monitor the germination and growth of the seeds by taking pictures every 12 hours for 14 Earth days.

You can perform the same experiment that will be performed on the moon. This is called a "Ground Control". Your data will help scientists determine the differences between growing plant on the Earth and the Moon.

Main Concepts

- Students will learn about conditions on the moon.
- Students will brainstorm questions about growing plants on the moon.
- Students will work in teams to build a germination chamber similar to the chamber being sent to the moon to answer their questions.
- Students should have a basic understanding of plant growth requirements.

Scientific Questions

Scientists are asking questions that can be used as an introduction to inquiry-based activities in your classroom. Some of the questions scientists are investigating about growing plants on the moon and ideas for inquiry based activities are:

- How much water will the plants require for a 14 Earth Day mission? Keep in mind that it costs approximately $ 50,000 to get 1 pound to the moon. Water weighs about 8 pounds per gallon students can determine the cost per fluid ounce or milliliter.
- What is the best type of seeds to use? Current possibilities are Wisconsin Fast plants (a type of mustard plant designed to germinate and grow to flower in 2 weeks) Cinnamon Basil (this was used on previous missions), rice, wheat. Students can brainstorm about what seed/plant characteristics are important for survival during launch, flight and landing for example tolerance to heat and cold, water requirements, how quickly they germinate and which seeds will result in plants astronauts can eat.
- How much light do the seeds need to germinate and how much will the plants need? This would be a good time to discuss the fact that a day on the moon (that is one total rotation) is 27.5 days. The seeds on the moon will be exposed to approximately Earth 14 days of sunlight.
- Is the color of the light important? Would it be beneficial to the seeds/plants to use a color filter on the window of the canister? Students could use colored plastic wrap for this investigation.
- How will we know that our mission is successful? Students can count the number of seeds that have germinated, the number that have cotyledons (the first leaves that form after germination), or the leaf area.
- What should we use in the bottom of the canister to hold the seeds and get the water to them? Filter paper, coffee filters, cotton? It is important that all the seeds get sufficient water to germinate. Also, if we measure the leaf area, we need the plants to stand up as straight as possible when they have developed leaves. What substrate is the best for the roots to attach to and support the plant?
- How many seeds and what pattern should we use to attach them to the material? The seeds must be attached to the substrate so they don't move during lift off and flight. Guar gum, a sticky plant extract, is being used. Are there other sticky substances that will dissolve with water? Could the seeds be pressed between 2 layers of filter paper?
- What temperature range will the dry seeds tolerate and still germinate? Students could freeze the seeds or heat them to high temperatures before putting them into the growth chamber.
- Would it be better for the container to be shiny on the inside and dark on the outside or is it better to have it be shiny on the outside also? A shiny inside should help to reflect the sunlight to the seeds.
- The students will be using food grade materials in the lesson but another question the scientists study is the biocompatability of materials that will be in the cylinder such as the plastics used for the window.

Your students will come up with many more questions.

Objectives

Student investigators will conduct ground control experiments and compare their plants to those grown on the moon. These student scientists will grow plants here on Earth in a similar container and under the same temperature and light conditions as those used in the moon growth chamber. These experiments should be started at the same time as the moon experiments so students will have real time data to report to the lunar scientists. Data will be shared via a website. (Website to be determined)

Abstract of Lesson

Student investigators will conduct ground control experiments and compare their plants to those grown on the moon. These student scientists will grow plants here on Earth in a similar container and under the same temperature and light conditions as those used in the moon growth chamber. These experiments should be started at the same time as the moon experiments so students will have real time data to report to the lunar scientists. Data will be shared via a website. (Website to be determined).

Prerequisite Concepts

Students should have a basic understanding of plant growth requirements.

Standards Met:

From BioEd Online, Baylor University (2011), *A Framework for K-12 Science Education*, National Research Council:
http://www.bioedonline.org/space/STS_Mission_134P.cfm#sub3

SCIENTIFIC AND ENGINEERING PRACTICES

- Asking question
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics, information and computer technology, and computational thinking
- Constructing explanations
- Obtaining, evaluating, and communicating information

LIFE SCIENCES

Structure and Function

Grades K-2

Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants.

Grades 3-5

Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

Grades 6-8

In multicellular organisms, the body is a system of multiple interacting subsystems and groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Grades 9-12

Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range.

Organization for Matter and Energy Flow in Organisms

Grades K-2

Plants need water and light to live and grow.

Grades 3-5

Animals and plants alike generally need to take in air and water, and plants need light and minerals.

Plants acquire their material for growth chiefly from air and water and process matter they have formed to maintain their internal conditions (e.g., at night).

Grades 6-8

Plants use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen.

Information Processing

Grades K-2

Plants respond to some external inputs (e.g., turn leaves toward the sun).

Grades 3-5

Different sense receptors are specialized for particular kinds of information.

Interdependent Relationships in Ecosystems

Grades K-2

Plants depend on air, water, minerals (in the soil), and light to grow.

Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight.

Grades 3-5

Organisms can survive only in environments in which their particular needs are met.

Materials List:

Per 2 students:

2 liter soda bottle
aluminum foil
rubber band
paper towels
seeds
plastic wrap
Strip thermometer
Plastic ruler
Seeds (Wisconsin Fast Plants®, basil, other small seeds)
Tweezers
Plastic ruler

For Class:

Protractor
Aquarium light
Web Camera
Software for time lapse photography

Procedure

Engage students with these introductory videos:

NASA kids video about living on the moon
http://www.youtube.com/watch?v=TNrhADcTNBk&feature=related

Video clip from National Geographic channel, " Living on the Moon"
http://www.youtube.com/watch?v=13XjkiASPxs&feature=relmfu

In a whole class discussion, brainstorm with students about what they know about the moon. Students can fill in the "know" section of the KWL chart individually or a whole class chart can be created (see Student Pages).

Use the questions below as a guide to fill in the W or "What questions are do you have?" section of the KWL chart.

The instructions below are for a test chamber that will allow students to measure leaf area, plant height and temperature. Depending on the questions the students are investigating, the amount of water or light may be changed, black paper could be attached to the outside of the container, or colored plastic could be added.

The changing angle of the light source for the plants is to simulate the path of the sunlight across the lunar surface. The sunlight takes a similar path on Earth but over a much shorter time period. By slightly changing the light angle each Earth day, the long lunar day is being simulated.

To prepare a test chamber:

1. Cut 2 liter soda bottle 2 to 3 cm below the shoulder so the bottle has straight sides. (The bottle biology website has tips for cutting soda bottles safe) See Resources). Cover the outside of the bottle with aluminum foil.
2. Copy a graph with 1 cm X 1cm squares onto a piece of paper towel. Download a graph and put the paper towel in the printer. (See resources for online graph paper) When viewing the chamber from above, this will help the students measure leaf area.
3. Cut the towel to fit the bottom of the bottle, a petri dish cover makes a good template. Cut into the paper towel circle so that there is a tab that will touch the bottom of the bottle. This will act as a wick for the water. See Figure 1.

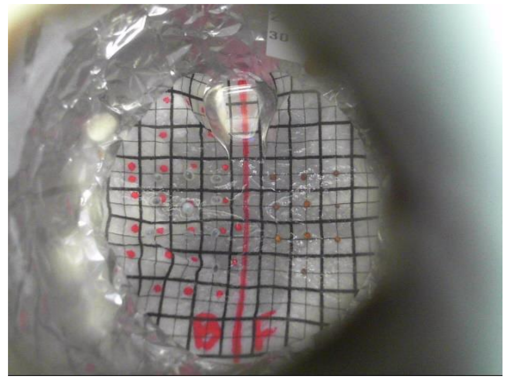


Fig. 1. Paper towel with graph and tab on bottom of the 2 liter bottle. One side has basil seeds, 1 side has Wisconsin Fast Plants®

4. Place the towel on the bottom of the bottle pushing the wick into one of the indentations.
5. Tape the thermometer to the side of the bottle.
6. Tape a small plastic ruler to the side of the bottle. This will help to measure plant height.

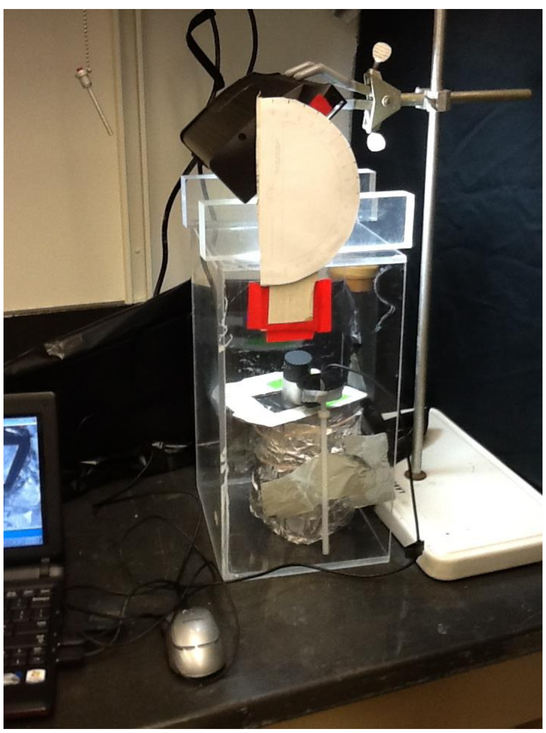


Fig. 2. Lunar plant chamber with camera and light.

7. Dampen the paper towel with a few drops of water. Add 10 ml of water to the indentation on the bottom of the bottle that contains the wick.
8. Carefully place 20 seeds onto the paper towel spread out as evenly as possible. Tweezers are helpful here.
9. Cover the top of the bottle with plastic wrap and secure it with a rubber band.
10. Cut a 5" X 5" piece of cardboard then cut a 2"X 2" square out that will let light into the bottle. The container that will be sent to the moon has a metal top with a 2" X 2" window.
11. Cut a hole for the web cam. Put the cardboard on the bottle.
12. Place the container under an aquarium light. To simulate the change of the angle of the sun light as it would be on the moon, the aquarium light can be angled from 180° to 90° using 10° increments then back from 90° to 180° each day. A protractor attached to the light stand can be used to measure the angle of light (see Figure 2).

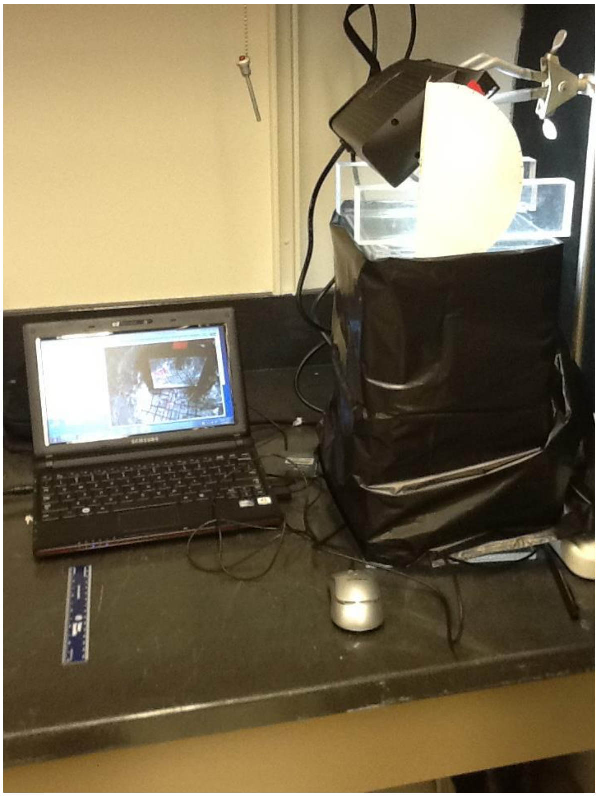


Figure 3. Black plastic surrounding chamber and camera

13. Place the web camera over the hole, flush to the plastic, this will prevent light reflections showing on the camera.
14. Attach web camera to the computer and start the time lapse software. Taking a photo every 30 minutes and putting the photos together using a movie making program on a computer (such as iMovie or Windows Live Movie Maker) will result in an interesting video showing seed germination and plant growth. This is also a great demonstration of geotropism and phototropism.
15. Surround the chamber and camera with black plastic to keep out as much of the room light as possible (see Figure 3).

Extensions

Students can design their own chamber that would be suitable to grow plants on the moon. Refer to a publication called ‘Packing up for the Moon’:

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Packing_Up_for_the_Moon.html

Resources

Plants in Space (Space Shuttle STS 118 mission video):

http://www.nasa.gov/mov/209112main_sts118_growing_plants.mov

Plants in Space (STS 134 Space Shuttle):

http://www.bioedonline.org/space/STS_Mission_134P.cfm

Bottle Biology:

http://www.bottlebiology.org/

science.howstuffworks.com/what-if-moon-colony.htm

Online graph paper:

http://incompetech.com/graphpaper/

Wisconsin Fast Plants®:

http://fastplants.org/

Cinnamon Basil Seeds: possible source

http://www.parkseed.com/

Web camera (Microsoft LifeCam):

Time delay software for webcam:

http://download.cnet.com/Webcam-Flix/3000-2348_4-10422269.html

http://www.softpedia.com/get/Internet/WebCam/Webcam-Flix.shtml

Student page 1

Names____ Period___________

Critical thinking questions:

1. Why do you think it is important for scientists to learn if plants can grow on other moons or planets?

2. Do you think that we should have a settlement on the Moon? Justify your answer.

3. Some scientists are thinking about terraforming other planets. Terra is the Greek word for Earth. What do you think terraforming means? Do you think it is a good idea? Why or why not?

Student Page 2

Names____ Period__________

Right now there are spacecraft orbiting and roving the surface of Mars, and a telescope called Kepler that is looking for stars that have planets orbiting around them. Wouldn't it be great to visit one of those planets someday? But first let's start with our own solar system. Some scientists and engineers think that the best way to explore Mars, and beyond is to start at the Moon. NASA may someday set up a settlement on the moon. If we were to live there, what would we need? Clean water, food and oxygen!! Plants can provide all of these things as well as help lunar settlers feel less homesick.

How is the environment on the moon different than that of the Earth?

Visit this website to fill in the blanks in the paragraph below:
http://coolcosmos.ipac.caltech.edu/cosmic_kids/AskKids/moon.shtml

The surface of the moon gets very hot and very cold, the temperatures can range from ____________ to ____________ in 1 day. But how long is a lunar day? On Earth at the equator, 1 day is approximately 12 hours of sunshine and 12 hours of darkness. At the Moon's equator 1 day is _________________ of sunshine and ___________ of darkness.
Because the moon does not have an atmosphere there is no wind and very little water. The other thing that is different on the moon is gravity. The moon has ___________ of the Earth's gravity.

Your Question:____

____

What is your control?

____

____

What will you measure to answer your question?

____

____

Draw a picture of your growth chamber on the back of this paper. Label the parts.

Names____ **Period**___________

Complete the chart below with your observations:

Day	Number of Seeds germinated	Number of Seeds with roots	Number of seed with 2 leaves	Number of plants with more than 2 leaves	Other Observations
Day 1					
Day 2					
Day 3					
Day 4					
Day 5					
Day 6					

Day 7					
Day 8					
Day 9					
Day 10					
Day 11					
Day 12					
Day 13					
Day 14					

Student Page 4

Names____ Period___________

What do I know about The Moon?	What Questions Do I have about the Moon?	What have I Learned?

Student Page 5

Names____ Period___________